Future Licensing and Inspection Readiness Assessment

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New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

Staff Requirements Memorandum

February 13, 2001

- Assess technical, licensing, and inspection capabilities
- Identify enhancements for reviewing/inspecting
  - Early site permits
  - License applications
  - Construction of new plants
- Assess 10 CFR 50 & 52 regulatory infrastructure
- Consider
  - Certified designs
  - Pebble Bed Modular Reactor
  - Other Generation 3+ and 4 light water reactors

Staff Considerations

- Critical skills and resources survey
- Industry plans and proposed schedules
- Previous licensing and pre-application reviews
- Effect of complex issues
- Previous resource and schedule evaluations

Technical, Licensing, and Inspection Capabilities

Skill gaps occur when individuals with expertise

- Are limited in number, working on important agency initiatives, or not in office where gap exists
- Are near retirement or are expected to leave the agency within 6 to 12 months
- Do not exist within the agency

Technical, Licensing, and Inspection Capabilities

Identified skill gaps

- Nearly all areas of site environmental reviews
- Historical and archeological resources
- Financial analysts
- Gas reactor and graphite technology
- Metallurgy and Chemical engineering
- HTGR accident analysis
- Construction inspectors in geotechnical areas (geology, hydrology, seismology)

New Licensing Activities

Conclusions

- Licensing processes in 10 CFR 52 are ready to be used
- Can complete current new reactor licensing activities
  - AP1000 Pre-application
  - PBMR Pre-application
  - 10 CFR 51 & 52 rulemaking
- Additional work needed to be ready for
  - Early site permits
  - License applications
  - Construction of new plants
- Priorities depend on number and timing of industry decisions to pursue new licensing activities

Future Commission Correspondence

■ Legal and Financial Issues	Nov. 2001
■ Exelon's Licensing Approach	Nov. 2001
■ AP1000 Phase 2 Review	Feb. 2002
■ Proposed Part 52 Revision	Apr. 2002
■ Alternative Regulatory Frameworks	Jun. 2002
■ PBMR Technical Issues	Jun. 2002
■ PBMR Policy Issues	Dec. 2002

Preliminary Perspectives on Exelon's PBMR Licensing Approach

Eric J. Benner, NRR

N. Prasad Kadambi, RES

Introduction

- December 5, 2000 Exelon requested early interactions with the staff on the feasibility of licensing the PBMR design in the United States.

- RES pre-application review of PBMR described in SECY-01-0070 (April 25, 2001)

- April 30, 2001: Exelon proposed a licensing approach based on a Modular High Temperature Gas Cooled reactor (MHTGR) framework developed by DOE in the 80's.

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Staff Activities to Date

- Development of an inter-office working group (NRR, RES and OGC) to evaluate Exelon's proposed licensing approach
- Monthly meetings with Exelon
- Supplemental meeting with Exelon to discuss screening of regulations and other topics
- August 14, 2001, brief of Risk-Informed Licensing Panel

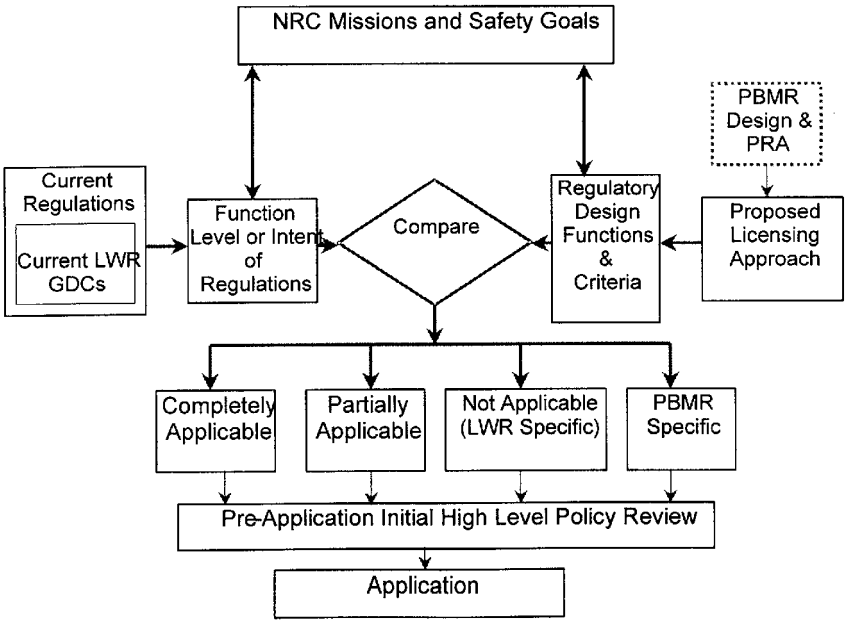
Staff Perspectives

Screening of Regulations

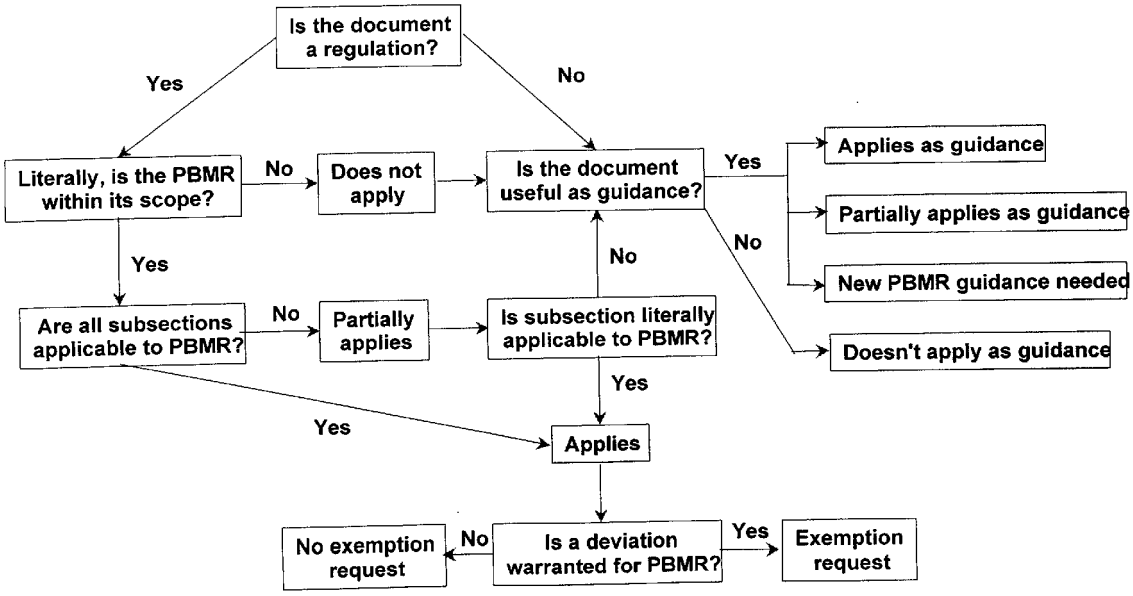
- Similar to MHTGR Pre-application draft Safety Evaluation and Ft. Saint Vrain Licensing
- Preliminary screening of regulations not assessed in detail because of need for design and design-analysis information to make a meaningful assessment
- Final decisions on applicability of regulations made by the regulator

Staff Perspectives

Exelon's Graphical Depiction of Screening of Regulations



Screening of Regulations: Exelon's Graphical Depiction of Logic Chart for Regulatory Document Review



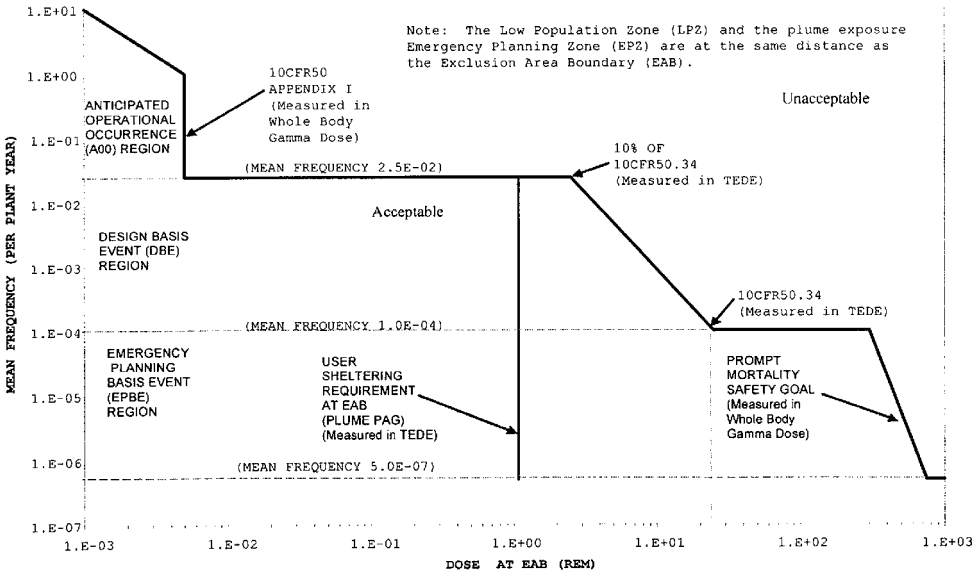
Staff Perspectives

General

- Appears to be a reasonable and structured method for screening regulations
- Staff will use risk-informed regulatory approach.
- Applicability of CDF and LERF?
- Regulatory Guide 1.174
  - Literally for design changes, principles are applicable
  - Defense-in-depth attributes
- Continued assurance of regulator independence is vital to public confidence in interactions

Staff's Perspectives

Top-Level Regulatory Criteria
Exelon's Proposed Frequency-Consequence Curve



Staff Perspectives

Top-Level Regulatory Criteria

- Plotting of TLRC is useful to illustrate bounding criteria
- Early fatality safety goal stated to be be most limiting; latent fatality safety goal also needs to be addressed
- Staff assessing lower cutoff for DBE region

Staff Perspectives

Licensing Basis Events

- Assurance needed that set of LBEs is reasonably complete, including bounding events
  - Objective of emergency planning
  - Spent fuel accidents
- Process for selection of LBEs: necessity for appropriate combination of deterministic and risk information
- Development of "source term" is necessary for assessing LBEs
- Validation of process requires design and design analysis information not currently available.

Staff Perspectives

Determination of Safety-Related Structures, Systems, and Components

- Licensing basis consists of set of requirements applied to safety-related SSCs.
- "Inherently reliable" components may need appropriate requirements because of uncertainties.
- Defense-in-depth also provided by non-safety-related SSCs
  - Importance of regulatory treatment of non-safety-related SSCs that serve to reduce safety system challenges

Staff Perspectives

Issues to be Considered in Staff Review

- Reasonable basis for adequate protection
- Treatment of uncertainties
- Safety margin
- Defense-in-depth
- Appropriate account of siting factors and safeguards
- Enhanced level of safety?

Future Staff Activities

- Staff will continue to interact with Exelon throughout the pre-application review
- Commission paper on staff's assessment due November 2001
- Staff will brief ACRS Future Plant Designs Subcommittee and/or ACRS Full Committee as necessary prior to Commission paper issuance

Exelon
Generation

Proposed Licensing Approach for the Pebble Bed Modular Reactor in the United States

Presented to the Advisory Committee on Reactor Safeguards

October 4, 2001

Presentation Outline

Exelon SM
Generation

- ❑ Exelon's Licensing Strategy
- ❑ Elements of the Licensing Approach
  - Top Level Regulatory Criteria (TLRC)
  - Process for identifying Pebble Bed Modular Reactor (PBMR) licensing bases events
  - Process of selecting Regulatory Design Criteria (RDC) and safety-related System, Structures, and Components (SSC)
  - Proposed approach to special treatment requirements
  - Process for identifying an applicable set of regulations
- ❑ Comparison with NRC Policy and Practice
  - Advanced Reactor Policy
  - Risk-Informed Guidance (e.g., Regulatory Guide (RG) 1.174, "An Approach for Using of PRA in Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis")
- ❑ Outcomes of Pre-Application Activities Related to the Licensing Approach

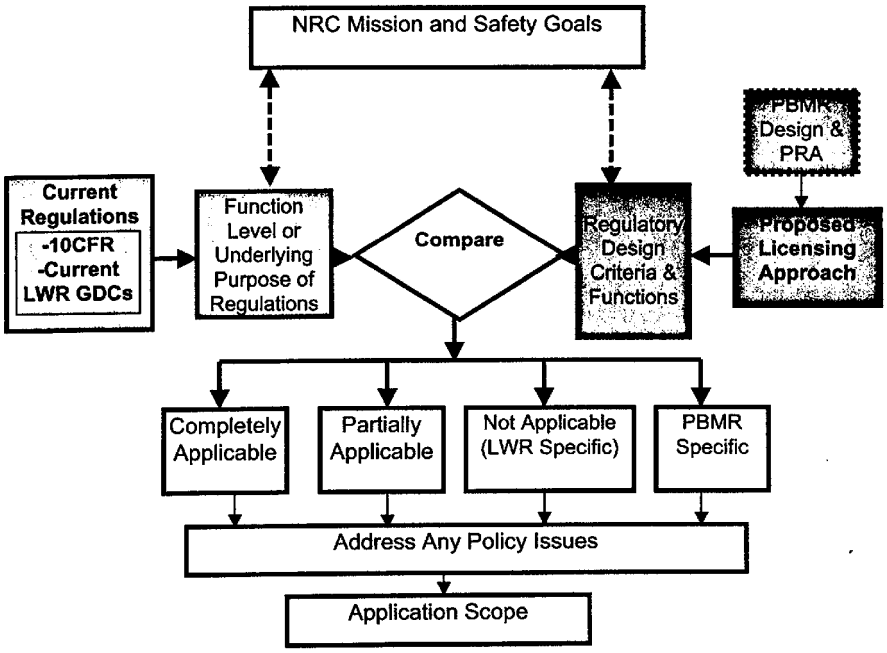
Licensing Strategy

- 10 CFR 52 - Combined License Application
- Build upon the design and review of the South African demonstration plant
- Use of current regulations
- Ensure there is a defined and stable licensing approach
  - Build on previous Modular High Temperature Gas-Cooled Reactor (MHTGR) work to develop licensing basis acceptance criteria
- Contemporary Probabilistic Risk Assessment (PRA) tools will be used to help establish the PBMR design basis

Elements Relative to the Licensing Approach

1. Top Level Regulatory Criteria (TLRC) establish *what* must be achieved
2. Licensing Basis Events (LBEs) define *when* the TLRC must be met
3. Regulatory Design Criteria (RDC) and safety-related equipment classification establish *how* it will be assured that the TLRC are met
4. Design conditions for and special treatment of safety-related SSC provide assurance as to *how well* the TLRC are satisfied
5. The above elements of the Licensing Approach will be used to determine the applicable regulatory requirements which will establish the *scope* of information to be provided in the license application

Licensing Approach



Element # 1.

Top Level Regulatory Criteria

- ☐ TLRC establish *what* must be achieved
- ☐ Selection principles:
  - Direct statements of acceptable health and safety as measured by risks of radiological consequences to the public
  - Quantifiable
  - Independent of reactor type and site

Limiting Top Level Regulatory Criteria for the PBMR

- 10CFR50 Appendix I – annualized offsite dose guidelines
  - *" Numerical Guidelines for Design Objectives and Limiting Conditions for Operation To Meet the Criterion "ALARA" for Radioactive Material in LWR Nuclear Power Reactor Effluents"*
    - **5 mrem/yr whole body**
- 10CFR50.34 - accident offsite doses
  - *"Contents of Applications"*
    - **25 rem total effective dose equivalent (TEDE)**
- EPA-400-R-92-001 - protective action guideline doses
  - *"Manual of Protective Action Guides and Protective Actions for Nuclear Incidents"*
    - **1 rem TEDE**
- NRC Safety Goal - individual prompt fatality risk
  - *"Safety Goals for the Operation of Nuclear Power Plants; Policy Statement (51 FR 149)"*
    - **$5x10^{-7}$/yr**

Element # 2.

Licensing Basis Events

- ❑ LBEs define *when* the TLRC must be met
- ❑ Off-normal or accident events will be evaluated for demonstrating compliance with the TLRC
- ❑ Collectively, analyzed in PRA for demonstrating conformance with the safety goal

Anticipated Operational Occurrences (AOOs)

- Events expected once or more in the plant lifetime
  - plant defined as having up to 10 reactors
  - a plant lifetime of 40 years assumed
  - lower frequency of 0.025/plant year
- Identified as families of events that could exceed criteria in 10 CFR 50, Appendix I *if certain equipment or design features had not been selected*
- Consequences realistically analyzed for compliance with 10CFR50, Appendix I

Design Basis Events

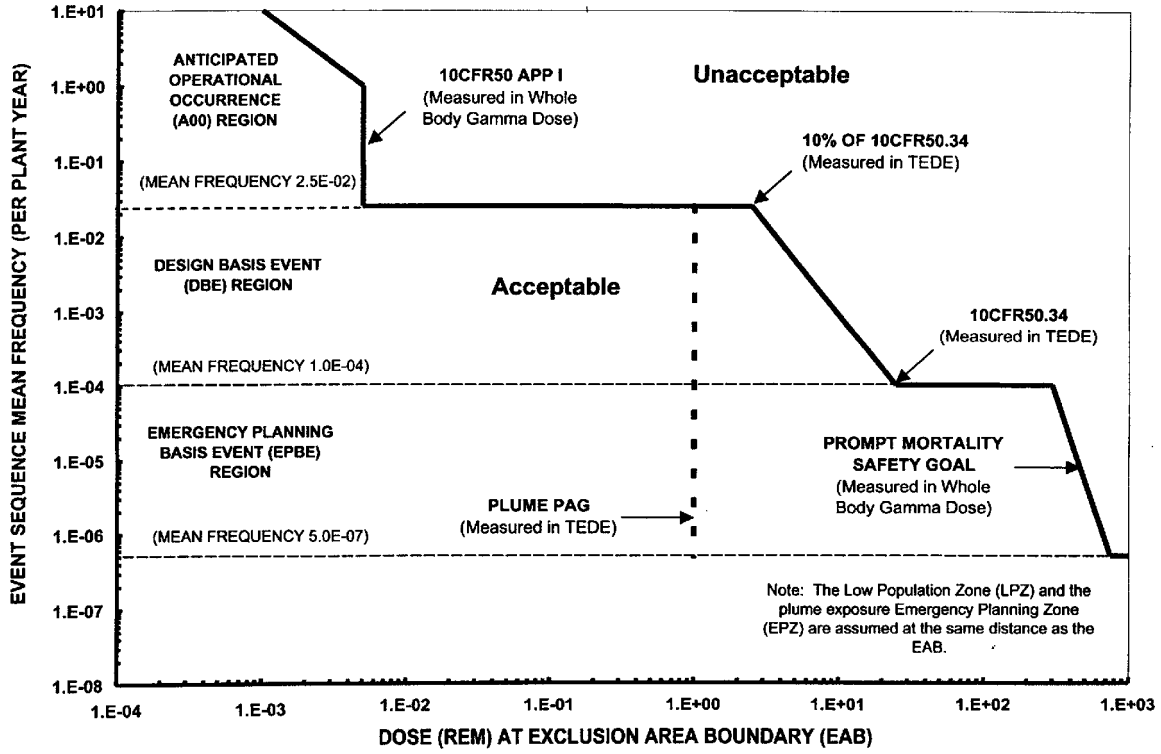
- Design Basis Events (DBEs) are events of lower frequency than AOOs, not expected to occur in the lifetime of the plant
  - lower boundary frequency of 10^{-4}/plant year
  - events at 10^{-4}/plant year have less than 1% chance of occurring
- Identified as families of events that could exceed 10CFR50.34 dose criteria *if certain equipment or design features had not been selected*
- Mean values and uncertainty range of consequences are evaluated to provide high confidence of compliance with 10CFR50.34 including safety margin

Emergency Planning Basis Event Region

- Events that are not expected to occur during the lifetime of a fleet of plants
  - lower frequency of 5×10^{-7}/ plant year
  - Consistent with prompt fatality safety goal
- Consequences realistically evaluated for compliance with Protective Action Guides (PAG) dose limits

PBMR Risk Criteria Chart with Top Level Regulatory Criteria

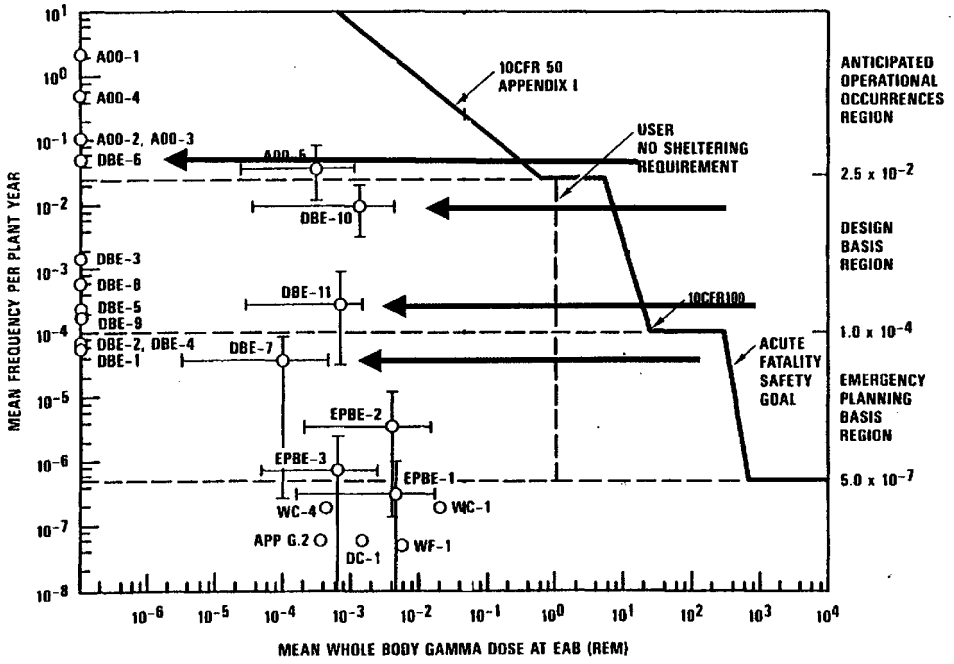
Exelon SM
Generation



PBMR PRA Scope Requirements

- Comprehensive treatment of initiating events, sequences, and end states
- Includes operating experience from power industry including Light Water Reactors (LWRs), Magnox, Advanced Gas Reactors (AGRs), and High Temperature Gas Reactors (HTGRs)
- PBMR PRA will address all modes of operation including shutdown, and internal / external events
- PBMR design characteristics support use of integrated event tree structure from initiating events to end states for accident family consequences and frequencies, including uncertainties

MHTGR Example for Selection of DBE



Required Safety Functions

- Required safety functions developed from review of LBEs in relation to TLRC
- Required safety functions expected to be similar to those for the MHTGR
  - for compliance with DBE region dose limits
    - radionuclide retention within fuel particles
    - control of heat generation
    - core heat removal
    - control of chemical attack

Element # 3.

PBMR Regulatory Design Criteria

- RDC establish *how* it will be assured that the TLRC are met
- Qualitative, functional statements for SSC classification as Safety-Related
- RDC are developed with risk insights for each required safety function
- PBMR specific RDC will supplement LWR General Design Criteria (GDC) i.e., 10 CFR 50, Appendix A

Selection of Safety-Related SSC

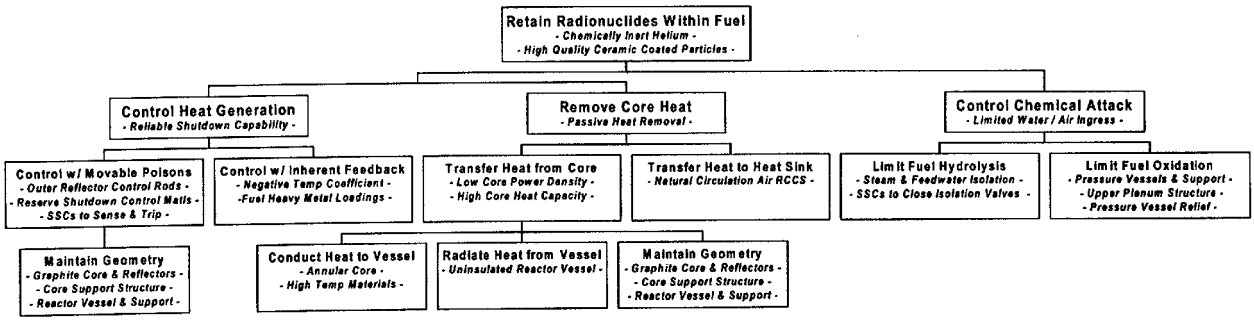
- Safety-related SSC provide assurance as to *how* the TLRC for DBEs are met

- Equipment relied on to perform the required safety functions to mitigate or prevent DBEs
  - Consequence mitigation: for DBE, SSC that are available and sufficient to perform the required safety functions to assure that the DBE dose criteria are met
  - High consequence prevention: for EPBE with doses greater than DBE dose criteria, SSC that are available and sufficient to perform the required safety functions to assure that the frequency of the event is below the DBE frequency boundary

MHTGR Selection of Safety-Related Equipment for Removal of Core Heat

SSC Available & Sufficient to Remove Core Heat During DBE?						
SSC	DBE 1	DBE 4	DBE 5	DBE 7	DBE 10	Safety-Related for this function?
Main Loop Cooling	No	No	No	No	No	No
Shutdown Cooling System	No	No	Yes	No	Yes	No
Reactor Cavity Cooling System	Yes	Yes	Yes	Yes	Yes	Yes
Reactor Cavity & Surroundings	Yes	Yes	Yes	Yes	Yes	No

Relation of MHTGR Safety-Related Equipment to Safety Functions



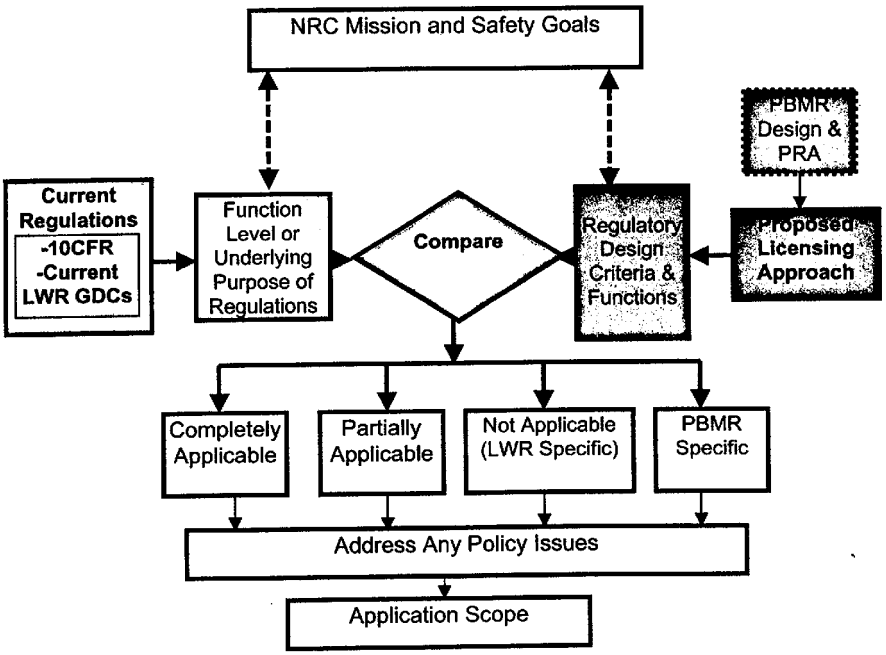
- Similar functional tree for PBMR to be developed showing SSC classified as safety-related

Element # 4

PBMR Approach to Special Treatment Requirements

- Design conditions for and special treatment of safety-related SSC provide assurance as to *how well* the TLRC are satisfied
- PBMR selection of safety-related equipment follows regulatory practice
  - DBE consequences shown to be acceptable using only safety-related equipment
  - classified equipment receives special treatment during design, fabrication, operation and maintenance
- The special treatment requirements for classified SSC will be developed based the required function for each DBE
- In this manner, a clear basis will be established for safety-related equipment selection and the corresponding quality requirements

Licensing Approach

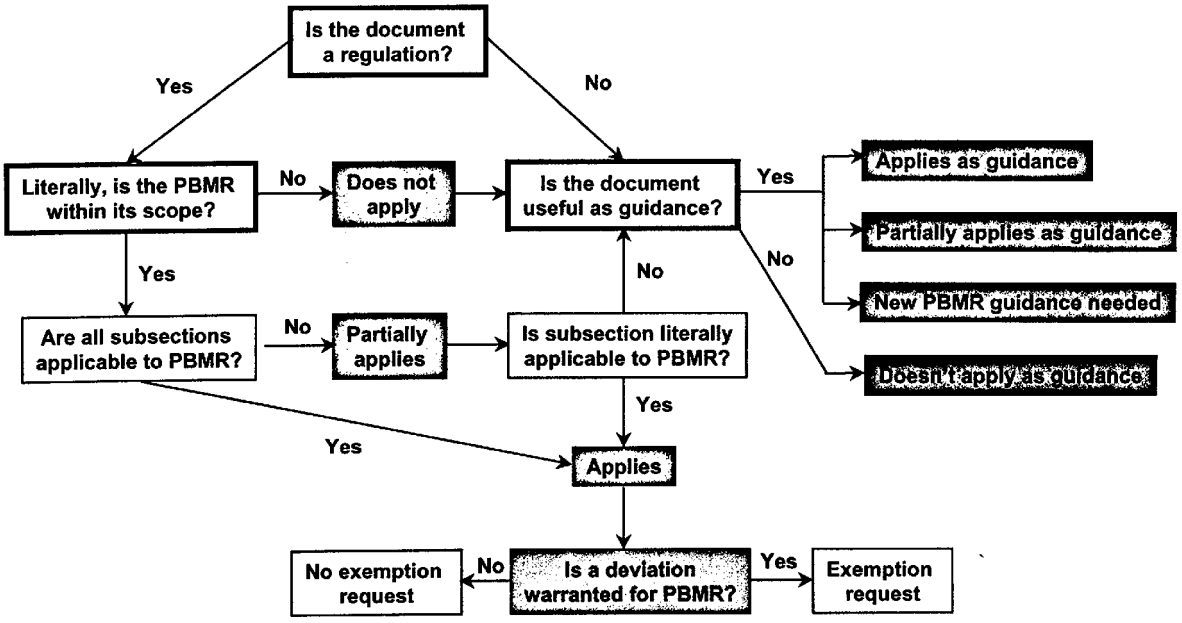


Element # 5

Determination of Applicable Regulatory Requirements

- The previously identified elements of the Licensing Approach will be used to determine the applicable regulatory requirements which will establish the *scope* of information to be provided in the license application
- An initial applicability screening of selected regulations was performed by Exelon
- Results of the four elements (e.g., LBE, RDC, SSC) will be used to conduct a more detailed applicability screening of regulations

Logic Diagram for Screening



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  - Proposed approach to special treatment of quality requirements
  - Process for identifying consistent set of regulations
- ➢ Comparison with NRC Policy and Practice
  - Advanced Reactor Policy
  - Risk-Informed Guidance (RG 1.174)
- ❑ Objectives of Pre-Application Activities

Comparison to NRC Advanced Reactor Policy

- Early Interactions

  Policy encourages " the earliest possible interactions of applicant, vendor and government agencies with the NRC."

- Safety Criteria

  Policy states that " the Commission expects, as a minimum, at least the same degree of protection of the public and the environment that is required of current generation LWRs."

- Licensing Approach

  "Advanced reactor designers are encouraged as part of their design submittals to propose specific review criteria or novel regulatory approaches which NRC might apply to their designs."

- Design Features

  Policy states that "the Commission expects that advanced reactors will provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions."

Comparison to RG 1.174 Framework for Risk-Informed Changes

- Applicable to license amendments
- Principles for risk-informed changes include the following
  - Consistent with defense-in-depth and balance between prevention and mitigation
  - Maintain sufficient safety margins
  - Changes small and consistent with Safety Goals
  - Changes monitored
- Provides useful guidance to evaluating the risk-informed aspects of the PBMR licensing approach

Outcomes of Pre-Application Activities Related to the Licensing Approach

- ❑ Agreement on TLRC
- ❑ Agreement on risk-informed LBE selection process
- ❑ Agreement on the process for equipment classification and the development of RDC
- ❑ Comments and feedback on the approach to special treatment of requirements
- ❑ Agreement on the process of determining PBMR applicable regulations and the reasonableness of a preliminary set of regulations
- ❑ Comments and feedback that PBMR licensing approach is consistent with NRC Policy and practices: Advanced Reactor Policy; An Approach for Using of PRA in Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis (Regulatory Guide 1.174)